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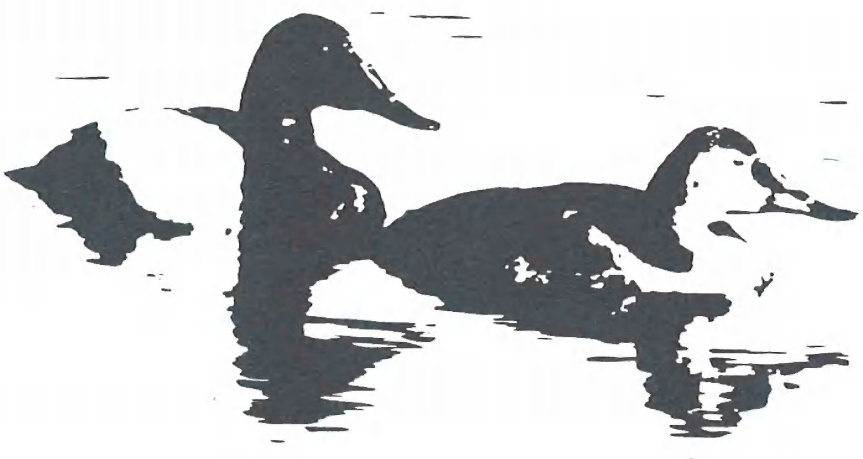
Habitat Use and Productivity of Canvasbacks in Southwestern Manitoba, 1961–72



UNITED STATES DEPARTMENT OF THE INTERIOR
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Special Scientific Report—Wildlife No. 248

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HABITAT USE AND PRODUCTIVITY OF CANVASBACKS IN SOUTHWESTERN MANITOBA, 1961–72

By Jerome H. Stoudt

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Foreword

An extensive drought throughout the glaciated prairie pothole region during the late 1950's and early 1960's focused attention on the status of the canvasback (*Aythya valisineria*). The impact of drought, in combination with habitat destruction, changing land use practices, and other factors resulted in reduced annual production. Special restrictive hunting regulations during that period provided additional protection to canvasbacks and redheads (*A. americana*).

Initiation of wetland preservation programs in the United States and Canada in 1960 created impetus for research on waterfowl breeding habitat. The U.S. Fish and Wildlife Service began a canvasback research project in 1961 to determine the impact of habitat loss and provide guidelines for habitat programs.

Jerome H. Stoudt participated in the cooperative United States and Canada waterfowl breeding ground survey from its inception in 1947. He served as one of the early flyway biologists and later as a research biologist. Because of his previous work on the Redvers study area in Saskatchewan and his long-standing personal interest in canvasbacks, he was chosen to serve as project leader to initiate this research effort. Throughout the course of this study, his concern for canvasbacks and his commitment to improving their status resulted in a wider appreciation of the multitude of problems confronting this species.

The Minnedosa study area was established in 1961 in the aspen parklands near Minnedosa in southwestern Manitoba. Historical information indicated that the densities of breeding canvasbacks were highest within the Minnedosa District. The study area contains above-average waterfowl habitat in terms of density and permanence of wetlands and includes some of the most productive natural waterfowl habitat in North America. For this reason, the Minnedosa area has been the setting for a series of intensive and extensive waterfowl investigations since the late 1940's.

As a wildlife biologist, Jerry pursued his studies vigorously by making detailed observations of canvasbacks, their life history, habitat requirements, and population status. He began this important work in the early 1950's, when wildlife as a science was in its infancy. The contents of this publication and its conclusions reflect the careful discrimination of an experienced field biologist. Jerry's observations over a 12-year period (1961–72) have provided valuable insight into the species biology and management potential of the canvasback. Current research on canvasbacks has elaborated on Jerry's earlier work and is designed to investigate key factors influencing annual productivity.

This publication is a testimonial to Jerry Stoudt for his personal and professional dedication to waterfowl and their future management in North America. Few among us have logged as many hours afield as Jerry did, or accumulated as much knowledge and experience, in a career that spanned 35 years with the U.S. Fish and Wildlife Service. In my view, this contribution is a tribute to Jerry's many achievements as a biologist and to his personal concern for the well-being of the canvasback.

Harvey K. Nelson, *Regional Director*
U.S. Fish and Wildlife Service
Minneapolis, Minnesota

Frontispiece. Hen canvasback protecting newly hatched brood in the Minnedosa study area, Manitoba. (Photo by Jerome H. Stoudt)

Habitat Use and Productivity of Canvasbacks in Southwestern Manitoba, 1961–72

by

Jerome H. Stoudt

U.S. Fish and Wildlife Service
Northern Prairie Wildlife Research Center
P.O. Box 1747
Jamestown, North Dakota 58401

Abstract

A study of canvasbacks (*Aythya valisineria*) breeding populations, nest success, productivity, and habitat requirements was conducted from 1961 to 1972 on a 181.3-km² area south of Minnedosa, Manitoba. Additional survey work was conducted in an area northwest of Minnedosa. These areas lie in the aspen parklands and are characterized by a diverse wetland complex. Land use in the region is primarily small grain farming, which has rapidly converted much of the woodland and grassland area to agriculture. Wetlands in early spring varied from 18 to 43/km² (average 26/km²) with a mean area of 0.5 ha. Most wetlands were 0.2 ha or less and ranged from 0.3 to 0.9 m deep. Seventy-one percent of the wetlands were located in cultivated land and a majority had open shorelines. Breeding pair populations ranged from 2.3 to 4.1/km² and were highest on Type 5 wetlands over 0.4 ha with less than one-third of the water surface covered with emergent vegetation. Nesting usually began the first week in May and success for 1,858 active nests from 1962 to 1972 ranged from 32 to 62% (average 45%). Hen success adjusted for renesting was 56%. Nesting canvasback hens most frequently used semipermanent (Type 4) wetlands less than 0.4 ha in area containing cattail (*Typha latifolia*) or hardstem bulrush (*Scirpus acutus*). No differences were found in nest success between wetland types. Of all canvasback nests examined, 57% were parasitized by redheads (*Aythya americana*). The average number of redhead eggs per parasitized nest was 3.2. Canvasback clutch size was reduced by about 1.0 egg in nests that were parasitized. More canvasback renests were parasitized by redheads than first nests. Predation accounted for 86% of the nest losses, and flooding, desertion, and burning made up the remainder. Raccoons (*Procyon lotor*) destroyed 64% of the nests lost to predators and accounted for 56% of all nest failures. Disturbance by field workers locating nests and flushing hens did not affect nest success. Mean brood size was 5.9, 5.6, and 5.3, for Class I, II, and III broods, respectively, and 5.8 for all broods. Juvenile mortality averaged 21% from hatching to Class II. Canvasback production totaled 1.5 broods/km² and averaged 7.7 young fledglings/km². Productivity (broods per pair) declined for the period 1949–55 to 1962–67 but numbers of broods/km² were not significantly different. Brood use was highest on semipermanent and permanent (Type 4 and 5) wetlands larger than 0.8 ha with less than one-third of the surface covered by emergent vegetation. Canvasbacks used a diversity of Type 3, 4, and 5 wetlands during the active breeding period for feeding, nesting, and brood rearing. Evidence suggests that canvasbacks require a secure nesting site in a diversified wetland complex containing a variety of size, permanency, and cover types.

An extensive drought in the prairie pothole region of the United States and Canada began to affect breeding habitat of canvasbacks (*Aythya valisineria*) as early as 1957 (Stoudt 1971). Continental breeding populations of this species began to decline and restrictive regulations were initiated in 1958 to lessen the effect of hunting on breeding populations (Reeves and Carney 1976). During the 1960–63 hunting seasons, a complete closure was imposed on canvasbacks in the United States to further protect remaining numbers. In view of the population status of canvasbacks and the new wetland habitat preservation programs begun during the post-drought period in the United States and Canada, it became imperative to learn as much as possible about breeding habitat requirements of this species. Consequently the U.S. Fish and Wildlife Service (FWS) initiated research on the breeding habitat requirements of canvasbacks in 1961. The principal purpose of this study was to gather basic information for establishing management programs to preserve and improve habitat for canvasbacks and other species of overwater nesting waterfowl.

One of the first major publications dealing with canvasback breeding biology was Hochbaum's (1944) classic, "The Canvasback on a Prairie Marsh." Most of this book dealt with canvasbacks on Delta Marsh, a habitat type particu-

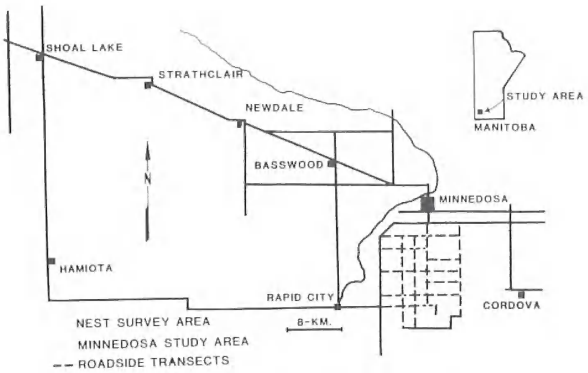

Fig. 1. Minnedosa study area and nest survey area.

larly important during drought periods, when most prairie potholes in southern Manitoba are dry. Erickson (1948) studied the life history and ecology of canvasbacks at Malheur National Wildlife Refuge in southeastern Oregon. Both Hochbaum and Erickson treated the general subject of habitat preference and use by canvasbacks.

Stewart et al. (1958) reported that canvasback breeding populations were widely dispersed over prairies of southern Canada and the northern United States, as indicated by extensive annual aerial waterfowl inventories conducted by FWS. Several intensive waterfowl studies in Alberta, Saskatchewan, and Manitoba also indicated that canvasbacks were common breeders in the Canadian parklands (Smith 1971; Stoudt 1971; Kiel et al. 1972). Olson (1964) conducted a study in southwestern Manitoba comparing canvasback productivity on small prairie potholes, a large marsh, and a large shallow lake during the drought years of 1959–61. Although the occurrence of breeding canvasbacks was well documented throughout the pothole region of Canada, little information has been published regarding habitat requirements.

The present work describes habitat relations of breeding canvasbacks in the aspen parklands of southwestern Manitoba near Minnedosa, during the 12-year period 1961–72. Principal objectives were to delineate major habitat types used by canvasbacks during the breeding period and to investigate annual production, cover types, water fluctuations, predation, weather, and other factors. The Minnedosa study area was selected because previous investigations (Evans 1949; Dzubin 1955; Olson 1964; Kiel et al. 1972) had indicated a high density of breeding canvasbacks in this region and had provided considerable background information.

Scientific names of animals and plants discussed in the text are listed in Appendix A.

Study Area

The Minnedosa study area is characterized by a diverse wetland complex ideal for breeding ducks (Kiel et al. 1972; Trauger and Stoudt 1974). Comparatively large, permanent wetlands are surrounded by excellent complexes of smaller wetlands that vary in permanency, size, shape, depth, vegetation, and land use. Quality of this waterfowl breeding habitat is influenced by a number of natural and human factors.

Fig. 2. Wetland density in the Minnedosa study area (1967).

The Minnedosa study area consisted of an extensive and an intensive unit within the Minnedosa District in southwestern Manitoba (Fig. 1). The intensive unit, south of Minnedosa, was used for counts of breeding pairs and broods, nest studies, and habitat appraisals. This unit consisted of a grid of roadside transects within a 181.3-km^2 area. These transects were 0.4 km wide (0.2 km on each side of the road) and covered a distance of 128.7 km (51.8 km^2). The intensive unit contained from 15 to 33.6 wetlands/km^2 in May between 1961 and 1972, depending on annual water conditions (Fig. 2). During the 12-year period the average number of ponds was 26.3/km^2. Sections (259.2 ha) in the center of the intensive study area contained more ponds than did those along western and eastern edges of the area. The extensive unit, which included wetland habitats between Minnedosa and Shoal Lake, Manitoba (Fig. 1), was used as a source of additional information on nests. Evans et al. (1952) and Kiel et al. (1972) described waterfowl breeding habitat of the Minnedosa District in detail.

Physiography

The Newdale till plain is the principal glacial landform in the Minnedosa area. It is characterized by an extensive

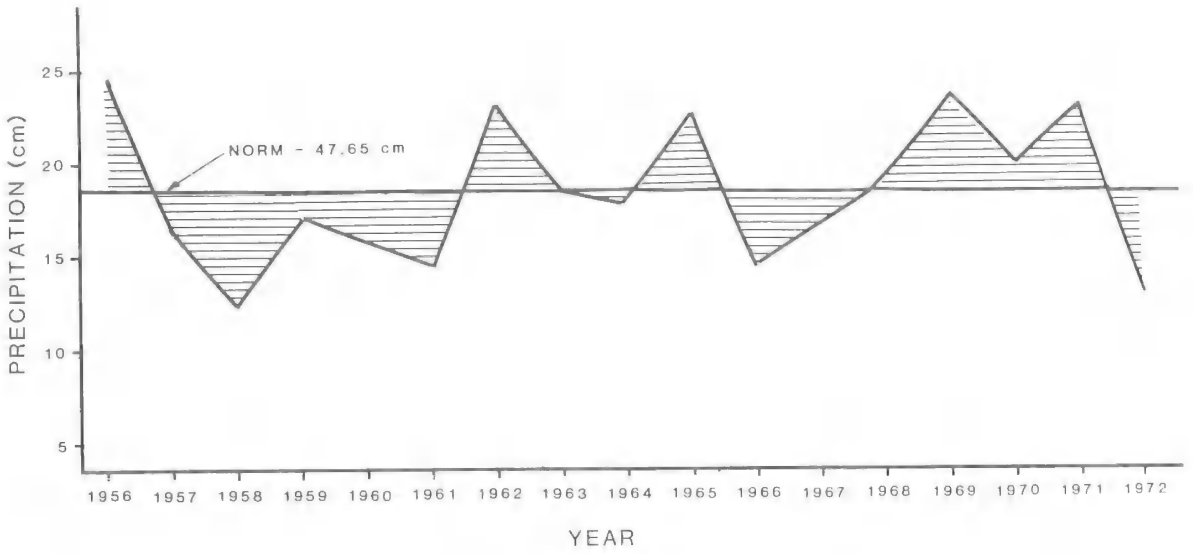

Fig. 3. Precipitation trends at Minnedosa, Manitoba, 1956–72.

ground moraine with level to undulating topography. Soils on the study area are black loam to clay loam, developed on medium-textured, moderately calcareous boulder till of mixed limestone, shale, and granitic rock origin (Ehrlich et al. 1957; Ehrlich and LeClaire 1958). This composition is classified as the Newdale association. Surface stones occur in soils throughout the area. Some terminal moraine deposits with slightly more abrupt topographic features and containing coarser-textured materials occur in the southeastern portion of the area.

The intensive study area south of Minnedosa lies within the Newdale smooth phase. Although the topography appears relatively flat, notable relief occurs in the form of low knolls and slight depressions. Small areas of degrading black and degrading black-meadow soils have developed under woodland invasion on northern and eastern slopes. Surface runoff and internal drainage are slow and a large percentage of the soils are imperfectly to poorly drained. The better drained Newdale soils are naturally fertile and well suited to production of grain and forage crops. These soils have good water retention capacity, are neutral to slightly alkaline in pH, and have high organic matter content.

The extensive area northwest of Minnedosa, which includes the towns of Basswood, Newdale, Strathclair, and Shoal Lake, lies in the Newdale undulating phase. Topography varies from roughly undulating to nearly level. Soils are more varied and include black-meadow and degrading black-meadow types. Soil drainage is variable. Runoff water from the knolls and ridges either accumulates in depressions or drains away through meandering, intermittent channels.

Climate and Weather

Weather data before October 1970 were recorded at Rivers, Manitoba, about 26 km southwest of the Minnedosa area (Canada Department of Transport 1950–72, unpublished data). Thereafter, because weather data were no longer available from Rivers, data from 32 km to the south, at Brandon, Manitoba, were used.

The mid-continental climate is characterized by extremes, with temperatures ranging from about −51° to 36° C. Strong winds are the rule, prevailing from the northwest. Long-term average precipitation for the Minnedosa area is 47.6 cm/year. Precipitation was below average in 1961, 1966, 1967, and 1972; heavy in 1962, 1965, 1969, and 1971; and near normal during the other four years of the study.

The severe drought on the Canadian prairies between 1958 and 1962 also adversely affected the Minnedosa parklands (Fig. 3). According to precipitation trends, the 1958–62 drought resulted from below normal precipitation in 1957–61. Between 1950 and 1972, 58% of the annual precipitation occurred during the May–August growing season. However, extremes of 9 cm in 1961 and nearly 40 cm in 1962 were recorded during these same months. Precipitation in the form of snow from December to March was relatively light and averaged only 8.7 cm, or 18.5% of the mean annual precipitation.

During the 12 summers of the study, mean precipitation was 0.3 cm above the norm, but was below the norm in May, June, and August and above the norm in July. Summers were wetter than normal in 1962, 1963, 1965, 1968, 1969, and 1971, and drier than normal in 1964, 1966, 1967,

1970, and 1972. The summer of 1961 was extremely dry.

Mean temperatures for the entire study period were similar to the long-term average and to the average for 1961–72. Mean monthly temperatures were never more than a few degrees above or below normal during the annual 4-month survey periods, but these monthly means masked the extremes.

Vegetation

The Minnedosa area has fewer trees and shrubs than typical parkland habitat because farming is intensive (Bird 1961). Small-grain farming (mostly wheat) and livestock production are the principal agricultural land uses. Quaking aspen is the principal tree; some bur oak occurs on the drier sites. Several species of willows occur around pond edges. Other typical shrubs are wolfberry, silverberry, beaked hazelnut, red osier dogwood, Wood's rose, chokecherry, pincherry, and Saskatoon berry. Herbaceous plants are numerous along roadsides and in non-agricultural areas.

Vertebrates

Among the 12 species of ducks that commonly nested on the area, blue-winged teal, mallards, and canvasbacks were the most abundant. American coots were the most abundant aquatic birds. Other common summer resident species included soras, horned grebes, pied-billed grebes, Franklin's gulls, and black terns. Avian predators included marsh hawks, red-tailed hawks, Swainson's hawks, and great horned owls. Common crows and black-billed magpies also occurred on the area.

The most common mammals were meadow voles, thirteen-lined ground squirrels, Franklin's ground squirrels, Richardson's ground squirrels, raccoons, and striped skunks. The most common large carnivores were red fox and coyotes. Red fox reportedly became more abundant after reduction of coyote populations by a 1080 poison bait program in the 1950's (A. Kruger, personal communication). Coyote numbers remained low throughout the study period. Raccoons invaded the area in 1954 (Kiel et al. 1972) and populations increased in subsequent years (Lynch 1971). Muskrats, badgers, snowshoe hares, white-tailed jackrabbits, and mink were also common.

Phenology

Among the indicators of spring phenology of the study area were first eggs laid by mallards and canvasbacks, first aspen leafing, first eggs by yellow-headed blackbirds and red-winged blackbirds, first dandelion blooming, first chokecherry blooming, and first coots hatching (Appendix B).

Habitat Quality

The Minnedosa parklands contained fewer trees than most parkland habitats and the area became more intensively cultivated each year during the study. Tree and brush removal accelerated in 1967. The region was primarily a small-grain farming area with less than one-fifth of the land in pasture and hayland (Evans et al. 1952; Kiel et al. 1972). Wheat was the predominent small-grain crop, followed by lesser amounts of barley, rapeseed, and oats. Nearly half the tillable land was fallowed each summer. The amount of spring burning and fall plowing each year varied. Because nearly half the cultivated land was fallowed from the year before, much of the area was barren soil when snow melted in spring.

Before 1965, wetland drainage was largely limited to small, temporary basins and probably had little effect on duck production. Drainage of the larger and more permanent wetlands accelerated in 1966 and 1967. Heavy rain during July of 1965 raised wetland levels over the entire study area and stimulated drainage efforts by landowners. Natural drainages were revealed when basin after basin filled up and spilled over into adjacent wetlands. In one section the drainage from the northwest corner through the southeast corner was so evident that the following spring two farmers used a backhoe to enlarge and deepen these natural drainage canals. By May 1966, water levels in about one-third of the ponds had been markedly lowered. By the early 1970's many Type 4 and 5 wetlands were eliminated by networks of ditches throughout entire sections of land.

Methods

Annual field investigations followed techniques described by Smith (1971) and Stoudt (1971). Various phenological events (Appendix B) were recorded from May 1 throughout the breeding season. These observations were made to provide information on seasonal events for comparison with that in other studies. Nest initiation dates were determined by backdating incubation stages of eggs by the flotation method (Westerskov 1950). Data on area and length were recorded in English units and later converted to the metric system (usually to the nearest significant digit).

Wetland Types

The number and acreages of wetlands on the intensive study area each May were recorded by type, size class, depth class, land use, vegetative class, and dominant emergent vegetation (Table 1). Wetland types on the study area were classified according to Shaw and Fredine (1956):

•Type 1 consisted of water in shallow depressions in pastures, meadows, croplands, or road ditches. Vegetative growth that followed drying of the basin was either of the upland type or the wet-meadow type (Fig. 4).

• Type 3 normally contained water in the spring but often dried up in late summer in all but the wettest years (Fig. 5). Whitetop was the dominant plant species, followed by sedges. Other species included spikerush and occasionally mannagrass, western waterplantain, waterparsnip, and rushes. Common cattail and hardstem bulrush occurred occasionally but only in small clumps or narrow bands.

• Type 4 usually contained water throughout the summer but occasionally dried up during hot, dry seasons (Fig. 6). Emergent vegetation included pure stands of cattail or hardstem bulrush or a mixture of these with whitetop, spikerush, and sedges.

• Type 5 included the deepest and most permanent of the wetlands (Fig. 7), which usually contained stands of emergent vegetation that ringed the pond, and sometimes had definite shorelines. Wetlands of this type were larger than those of other types and contained aquatic vegetation such as common watermilfoil, star duckweed, common duckweed, common bladderwort, and sago pondweed. Muskgrass sometimes carpeted and shaded the pond bottoms.

Table 1. *Mean yearly number and area of May wetlands on transects, by types, in the Minnedosa study area, 1962–72.*

Wetland types[a]	Number		Area (ha)	
	Mean	Per km²	Mean	Per km²
1	220	4.3	21.5	0.4
3	478	9.3	77.0	1.5
4	264	5.0	104.9	2.0
5	393	7.7	403.0	7.8
Total	1,355	26.3	606.7	11.7

[a]Wetland type 2 was not represented.

Wetlands were also categorized by size and depth. Water fluctuations were monitored annually for six Type 5 wet-

Fig. 4. Type 1 wetland (Shaw and Fredine 1956) in the Minnedosa study area.

Fig. 5. Type 3 wetland (Shaw and Fredine 1956) in the Minnedosa study area.

lands at about 10-day intervals. Estimates of water depths were made for other wetlands. Trends in water levels were measured by water gauges in selected wetlands throughout the study area.

Land Use

Wetlands were also classified according to the predominant type of use of adjacent land. Where more than one land use occurred around a wetland, the dominant land use was considered to have the greatest effect on waterfowl use. Most wetlands – especially those 2 ha or smaller – were surrounded by land of a single use type. Wetlands in roadside ditches were recorded as ungrazed grassland, even though the perimeters of some were cut for hay in July.

In the Minnedosa area, wetland perimeters tended to be less wooded than in most of the aspen parklands and were classified by peripheral and emergent vegetation. If less than one-third of the shoreline was bordered with aspen or willows, the wetland was classified as "open"; if trees grew on one-third to two-thirds of the shoreline, it was classified as "half"; and if tree growth occupied more than two-thirds of the edge, it was classified as "closed."

Emergent aquatic vegetation was classified in the same way. An "open–open" wetland was one with tree or willow growth along less than one-third of its shoreline and whose surface was less than one-third vegetated. A "closed–closed" wetland had over two-thirds of its shoreline wooded and over two-thirds of its water surface vegetated.

Percentage of water surface covered by emergent aquatics was estimated for each pond and was classified into four categories: 0–10%, 11–33%, 34–66%, and 67–100%. In addition, dominant plant species and percentage of each were recorded.

Fig. 6. Type 4 wetland (Shaw and Fredine 1956) in the Minnedosa study area.

Pair Counts

Pairs of canvasbacks were counted from roadside transects and within "beat-out" areas (waterfowl census technique, Stoudt 1971). Four or five roadside counts were made at about 10-day intervals, beginning the first week in May each year. These counts provided information on peak populations of breeding pairs, chronology of the nesting season, from ratios of drakes to pairs, and an indication of success of early nesting hens.

Beat-out counts of breeding pairs were made from 1963 to 1966 on a 7.8-km^2 block study area. In 1967, these counts were extended to the 51.8-km^2 roadside transect system. Counts were conducted in mid-May and early June on all ponds within the block or transect.

Reasonably accurate counts of breeding canvasbacks were obtained on the beat-out areas by counting all pairs and lone drakes. Pairs plus lone drakes were used to calculate total pairs. Flocked drakes were assumed to have hens nesting outside the study area and were not counted. Lone hens were not counted on roadside census areas unless they had a nest; they usually represented less than 3% of the indicated pairs. Counts on beat-out areas along roadsides were not conducted during storms or when winds exceeded 24 km/h. All counts were made between 0730 and 1800 h and an attempt was made to include the same number of morning and afternoon hours on each count.

Nest Searches

Canvasback nests were found by wading through stands of emergent vegetation. Searches were limited to wetlands that contained overwater nest cover of sufficient density

Fig. 7. Type 5 wetland (Shaw and Fredine 1956) in the Minnedosa study area.

to support nests. During early May, nest cover was limited to vegetation that remained standing from the previous year. Wetlands with a known history of canvasback nests were searched each year. Nest searching on the extensive study area was generally confined to the areas of known or suspected use because the objective was to find as many nests as possible.

When a hen was seen on a nest before she flushed, the searchers did not disturb her. Hens which were never flushed yielded information regarding possible bias in nest success caused by flushing. However, most canvasback nests were found by flushing the hen and then locating the nest. Nests deserted due to disturbance by the search crew were not included in calculations of nest success.

When a nest was located, data were recorded at the site, the eggs were covered with down, and the observers left the site quickly to avoid further disturbing the hen or attracting predators. Data were collected on nest material, nest cover, clutch size, incubation stage, and egg parasitism. Care was taken to straighten trampled cover and leave as little sign as possible near the nest. A willow stick with a plastic or cloth marker was placed 9 m or more from the nest. Nest data were recorded on individual survey forms. Most nests were revisited after expected hatching dates to determine success, parasitism by redheads, and other factors. Most nests were rechecked after violent storms.

Brood Counts

Brood surveys were conducted on the same areas used for breeding pair counts. Additional data were obtained from observations made in areas adjacent to the transects.

Table 2. *Mean yearly number and area of May wetlands on transects, by size classes, in the Minnedosa study area, 1962–72.*

Size class (ha)	Number		Area (ha)	
	Mean	Per km²	Mean	Per km²
0.3–1.2	766	14.7	79.4	1.5
1.3–2.5	215	4.3	69.3	1.3
2.5–5.0	166	3.1	106.1	2.1
5.0–12.4	167	3.1	230.9	4.5
12.4–24.7	38	0.8	105.3	2.0
>24.7	3	0.1	16.2	0.3
Total	1,355	26.3	606.7	11.7

Table 3. *Mean yearly number and area of May wetlands on transects, by depth classes, in the Minnedosa study area, 1963–68 and 1970–72.*

Depth class (cm)	Number		Area (ha)	
	Mean	Per km²	Mean	Per km²
0–30	334	6.6	31.6	0.6
30–60	471	9.3	105.3	2.0
60–91	451	8.9	322.0	6.2
>91	125	2.3	159.2	3.1
Total	1,381	26.6	616.4	11.9

Data on brood size were obtained from transects, beat-out counts, and general observations on or adjacent to the study area. Counts of canvasbacks along roads were made 2–3 h after sunrise and 2–3 h before sunset. On cloudy days with light winds, counts were made during two 3-h periods, early and late. On clear days with moderate winds, only 2-h counts were made morning and evening. No counts were made during high winds or heavy rain. Broods on selected transects were counted by walking along the shoreline of each pond and flushing them into open water. A dog was used on ponds with wide bands of emergent vegetation.

Canvasback broods were comparatively easy to count by the beat-out method or from roadsides because hens usually led their broods into the deeper, open water areas. One count per season was adequate to locate most canvasback broods. Canvasback ducklings require 8 weeks to attain flight stage, and by the time early broods reach that stage the eggs in the latest nests have usually hatched (Dzubin 1959).

Broods were classified by three age classes (I, 1 to 25 days; II, 26 to 53 days; III, 54 to 65 days) described by J. B. Gollop and W. H. Marshall (unpublished report). Habitat data were recorded for ponds on which broods were observed.

Table 4. *Mean yearly number and area of May wetlands on transects, by land use types, in the Minnedosa study area, 1962–72.*

Land use type	Number		Area (ha)	
	Mean	Per km²	Mean	Per km²
Fallowed or plowed	731	14.3	327.2	6.3
Stubble	228	4.2	104.1	2.0
Ungrazed grassland	172	3.5	63.2	1.2
Grassland pasture	137	2.7	77.8	1.5
Ungrazed woodland	28	0.4	7.3	0.1
Woodland pasture	30	0.4	12.6	0.2
Hay crops	25	0.4	10.1	0.0
Grain crops	5	0.4	3.2	–
Total	1,355	26.3	606.7	11.7

Results

Wetlands

In May, Type 3 wetlands were the most abundant on the study area, followed by Type 5 and Type 4 (Table 1). Two-thirds of the total acreage of wetlands was semipermanent (Type 5). The area of such wetlands ranged from 0.2 to 4 ha. The reduction in sampling area starting in 1962 resulted in deletion of all wetlands that exceeded 4 ha.

Among the May wetlands, 72% occupied 0.4 ha or less and represented 24% of the total acreage (Table 2); 67% (69% of the total acreage) ranged from 33 to 91 cm in depth (Table 3). Cultivated land surrounded 71% of the wetlands and represented 71% of the total acreage (Table 4).

About 71% of the wetlands on the study area had both open shorelines and open surfaces during early May (Table 5); 89% had open shorelines; and in about 5%, more than two-thirds of the shoreline was closed by aspen or willows.

Among emergent plants, whitetop was the dominant vegetation in most of the wetlands (Table 6), although in

Table 5. *Mean yearly number and area of May wetlands on transects, by vegetative classes, in the Minnedosa study area, 1962–72.*

Vegetative class[a]	Number		Area (ha)	
	Mean	Per km²	Mean	Per km²
Open–open	967	18.9	501.8	9.7
Open–half	150	3.1	38.5	0.7
Open–closed	87	1.5	16.6	0.3
Half–open	70	1.2	32.8	0.6
Half–half	11	0.4	3.7	0.1
Half–closed	5	T[b]	1.6	0.0
Closed–open	48	0.8	9.3	0.2
Closed–half	13	0.4	2.0	0.0
Closed–closed	5	T	0.4	0.0
Total	1,355	26.3	606.7	11.7

[a]Proportion of the wetland surrounded by trees and proportion of water surface covered by emergent aquatics: shoreline–pond surface.
[b]Trace.

Table 6. *Mean yearly number and area of May wetlands on transects, by dominant emergent vegetation, in the Minnedosa study area, 1962–72.*

Dominant emergent vegetation	Number		Area (ha)	
	Mean	Per km²	Mean	Per km²
None	395	7.7	142.6	2.8
Whitetop	357	7.0	83.8	1.6
Cattail	206	3.9	96.4	1.9
Mixed[a]	254	5.0	161.6	3.1
Bulrush[b]	107	1.9	117.1	2.3
Willows	36	0.8	5.7	0.2
Total	1,355	26.3	606.7	11.7

[a]Mixture of bulrush, cattail, and whitetop.
[b]Mainly hardstem bulrush.

1972, the number and size of wetlands containing whitetop were reduced considerably by high water. Hardstem bulrush was also plentiful. Wetlands with dense stands of bulrush along the shoreline were typical, especially early in the season before the emergence of whitetop, when residual bulrush remained from the previous season.

Less than 10% of the surface of 61% of the ponds was covered by emergents in early May (Table 7). The larger wetlands were usually the deeper, and the fringe of emergent plants was usually narrower than in the smaller wetlands.

Water Levels

Mean water levels were 66 cm higher in 1972 than in 1962. Both water levels and numbers of wetlands decreased markedly in 1968, apparently because precipitation was below normal in both 1966 and 1967. A 13.5-cm deficiency in rainfall occurred during the last 8 months of 1967.

The poor relation between wetland numbers and water levels in 1971 and 1972 was caused by extremely high water, which often resulted in the joining of two or more ponds into a single body of water. Several residents in the area stated that water levels in 1972 were the highest they could remember.

Breeding Populations

Migrant flocks of canvasbacks enroute to nesting grounds are usually characterized by high ratios of males to females—often as high as 2:1 (Bellrose et al. 1961). This ratio decreased soon after the birds arrived. Transect counts that measured chronological changes in breeding pair populations showed that the best time to determine breeding densities was at the peak of the nesting season. Olson (1964) reported that most of the drakes left the breeding area soon after nesting began and prevented an accurate estimate of the breeding numbers. The present study supported these conclusions. Breeding pair estimates seem most reliable when the drake to pair ratio reaches 1:1. At least half the hens at that time are on nests or have initiated nesting, and drakes have not yet left the area. This ratio was reached between 5 and 25 May in most years, and most frequently before 15 May. Breeding populations counted along roadside transects are shown in Table 8. Transect data in 1961 were not directly comparable but indicated a breeding population of at least 2.3 pairs/km².

Two sections that were intensively searched for canvasback pairs and nests in this study encompassed the former Roseneath study area reported by Dzubin (1952:73, 1955:68). Breeding pair densities from 1949 to 1955 on the Roseneath area were compared with those found in the present study between 1963 and 1967. Average canvasback densities (breeding pairs/km²) were 3.13 ± 0.85 in 1949–55 and 3.84 ± 0.73 in 1963–67. These densities were not significantly different (t-test; $P > 0.05$). Pair counts were not made on this area after 1967 because drainage was so intensive that the habitat was severely altered and waterfowl populations were no longer representative of the general study area.

Table 7. *Number and area of May wetlands by percent cover of emergent vegetation in the Minnedosa study area, 1962–72.*

	Percent coverage								Wetlands per km² per year	
	0–10		11–33		34–66		67–100			
Species	No.	Ha	No.	Ha	No.	Ha	No.	Ha	No.	Ha
Open	4,378	1,568.2	—	—	—	—	—	—	7.7	7.0
Whitetop	1,479	421.2	1,083	263.3	702	134.1	623	101.7	7.0	3.9
Cattail	956	539.5	715	358.0	482	140.9	124	26.3	3.9	4.6
Mixed	1,284	1,141.7	722	428.9	509	147.4	251	59.5	5.0	7.7
Bulrush	832	998.3	321	270.1	31	17.4	3	—	1.9	5.4
Willows	200	30.0	130	19.9	69	8.1	6	—	0.8	0.4
Total	9,129	4,698.8	2,971	1,340.2	1,793	447.9	1,007	187.5		
Mean	830	427.3	270	122.3	163	40.9	92	17.0	26.3	29.0
Percent	61	70	20	20	12	7	7	3		

Table 8. *Number of breeding canvasback pairs on the Minnedosa study area, 1962–72.*

Date	Drakes	Pairs	Total pairs No.	Total pairs No./km²
24–25 May 1962	70	71	141	2.7
10–15 May 1963	101	94	195	3.8
11–15 May 1964	110	93	203	3.9
24–28 May 1965	132	78	210	4.1
22–23 May 1966	80	82	162	3.1
22–23 May 1967	72	66	138	2.7
9–10 May 1968	54	96	150	2.9
21–22 May 1969	112	20	132	2.6
22 May 1970	74	36	110	2.1
24 May 1971	92	30	122	2.4
20–21 May 1972	79	33	112	2.2
Mean	89	64	152	2.9

Habitat Use

Type 5 wetlands were used most by canvasback breeding pairs, followed by Type 4 (Table 9). Of all pairs recorded on transects, 83% were on Type 5 wetlands and less than 0.5% on Type 1. Although 57% of the wetlands on the study area amounted to 0.2 ha or less, the greatest use by canvasbacks was of wetlands between 0.4 and 2 ha (Table 10). Wetlands within these size classes contained 55% of the total wetland area. Water depth exceeded 91 cm in 9% of the wetlands, but because most of these wetlands were large they made up 26% of the total wetland area and were used by 30% of the breeding pairs (Table 11). Highest use per hectare was on wetlands more than 0.6 m deep.

Type 4 and 5 wetlands surrounded by plowed fields were used by 50% of the pairs; such wetlands made up 54% of the total wetland area. About 24% of the pairs used wetlands located in pasture—a use per unit of area considerably above the mean (Table 12). Open water wetlands were used by 88% of the pairs (Table 13). Wetlands with open surfaces were used more heavily than those with appreciable amounts of emergent vegetation. Pair use per hectare was highest on wetlands with half-wooded shorelines and open water surfaces. Breeding pair use was highest on wetlands dominated by hardstem bulrush (Table 14); wetlands containing cattails ranked second, and open wetlands containing no emergents third.

Table 9. *Canvasback pair use in relation to wetland type in the Minnedosa study area, 1962–72.*

Wetland type	Total pairs	Pairs per wetland ha
1	7	0.0
3	82	0.1
4	231	0.2
5	1,363	0.3

Table 10. *Canvasback pair use in relation to pond size in the Minnedosa study area, 1962–72.*

Area (ha)	Total pairs	Pairs per wetland ha
0–0.2	116	0.1
0.2–0.4	164	0.2
0.4–0.8	347	0.3
0.8–2.0	644	0.3
>2.0	412	0.3

Table 11. *Canvasback pair use in relation to wetland depth in the Minnedosa study area, 1963–72.*[a]

Depth (cm)	Total pairs	Pairs per wetland ha
0–30	10	0.0
31–61	132	0.2
62–91	924	0.3
>91	451	0.3

[a]Depths not recorded in 1969.

Table 12. *Canvasback pair use in relation to land use in the Minnedosa study area, 1962–72.*

Land use type	Total pairs	Pairs per wetland ha
Grassland pasture	345	0.4
Wooded pasture	59	0.4
Ungrazed woodland	27	0.4
Ungrazed grassland	183	0.3
Plowing or summer fallow	839	0.2
Hay crops	23	0.2
Stubble	207	0.2

Table 13. *Canvasback pair use in relation to cover type in the Minnedosa study area, 1962–72.*

Cover type[a]	Total pairs	Pairs per wetland ha
Open–open	1,476	0.3
Open–half	66	0.2
Open–closed	7	0.1
Half–open	115	0.3
Half–half	2	0.1
Half–closed	1	0.1
Closed–open	14	0.2
Closed–half	1	0.1
Closed–closed	1	0.2

[a]Shoreline–pond surface.

Table 14. *Canvasback pair use in relation to emergent cover in the Minnedosa study area, 1962–72.*

Emergent vegetation	Total pairs	Pairs per wetland ha
Hardstem bulrush	438	0.4
Cattail	289	0.3
Mixed	386	0.2
Whitetop	179	0.2
Willows	6	0.1
None	385	0.3

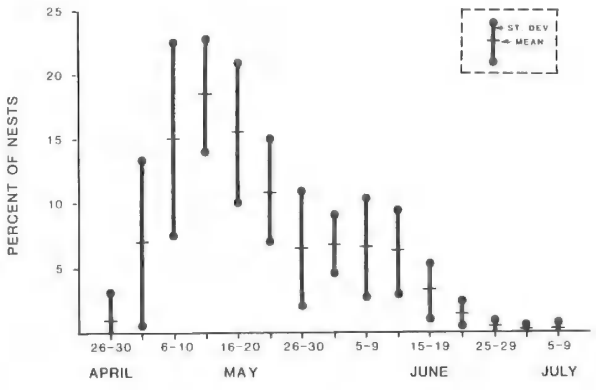

Fig. 8. Chronology of canvasback nesting in the Minnedosa study area, 1961–72.

Nesting Chronology

Chronology of nesting was determined for all nests where it was possible to backdate the laying of the first egg. There was often an observable difference in success between early and late nesting attempts. As the season progressed, the current year's growth of vegetation attained sufficient height and density to afford additional cover for late-nesting or renesting canvasback hens. Although nesting attempts began as early as 26 April, the first attempts peaked between 6 and 20 May (Fig. 8). First nesting attempts peaked from 6 to 15 May during 10 of the 12 years; the peak was 10 days later in 1961 and 1962, which were both drought years.

In 1962 there was a gradual buildup to the first nesting peak during 16–20 May, followed by a tapering off until a second peak occurred 5–9 June (Fig. 9). The 1969 data indicated a rapid buildup of initial nesting attempts to a peak during 6–10 May, and few first attempts after 16–20 May. Early nesting success was comparatively high that year. Cold weather, flooding, and predation by raccoons caused poor early nest success in 1965, but a strong second nesting effort peaked during 5–9 June.

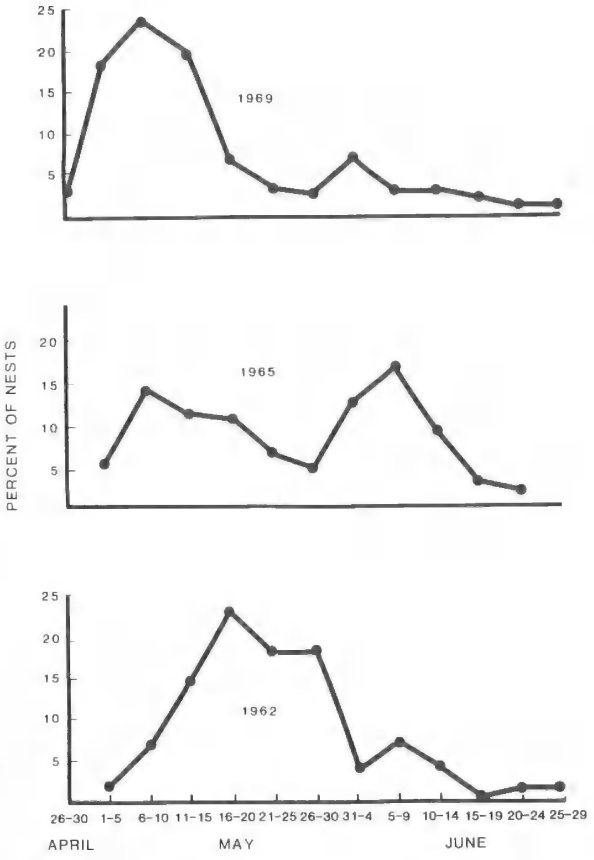

Fig. 9. Variations in nesting chronology of canvasbacks in the Minnedosa study area.

Nest Success

During the 12-year period, 2,511 canvasback nests were found, of which 841 (45%) were successful (Table 15). Nesting success differed among the various units of the study area from 1963 to 1972; nests south of the intensive study unit were less successful than those northwest of it (Table 16).

Some overlap occurred between first and second nesting attempts but the period when first attempts had practically ended and renesting had started was usually discernible when the data were arranged by 5-day periods (Fig. 9). Most first nesting attempts ended and substantial renesting usually began between late May and early June. The renesting effort was apparently not closely related to phenology of the previous month nor to chronology of the first nest initiation, but appeared to be more closely related to predation. Peak dates of the renesting effort did not vary more than 10 days among the 12 years of the study.

Several sources of information were used to adjust data to reflect the actual number of hens that renested. In addition to these data, breeding pair and brood data from beat-out counts were used to determine the percentage of hens that renested. Data from 1966 (Fig. 8 and Table 15) are presented as examples of adjusted nesting data: First nesting (19 April–26 May), 115 nests; success from 115 nests, 47%; renesting (27 May–29 June), 58 nests; success from 58 nests, 55%.

Breeding pair and brood data from a 7.8-km^2 block within the study area south of Minnedosa were used to calculate the percentage of canvasback hens that renested. Inasmuch as 32 breeding pairs were found on this area in 1966, and nesting success was 47%, the 32 hens should have produced 15 broods on the first nesting attempt. The remaining hens might have renested, but in late July the

Table 15. *Nesting success of canvasbacks in the Minnedosa District, 1961–72.*

Year	Number of nests					Percent successful
	Found	Active	Usable[a]	Failed	Hatched	
1961	102	90	90	61	29	32
1962	185	156	134	73	61	46
1963	238	196	180	99	81	45
1964	227	187	156	67	89	57
1965	298	207	198	133	65	33
1966	232	181	173	87	86	50
1967	252	192	179	115	64	36
1968	253	159	152	120	32	21
1969	203	163	162	62	100	62
1970	177	148	141	64	77	55
1971	175	160	153	63	90	59
1972	169	146	140	73	67	48
Total	2,511	1,985	1,858	1,017	841	45

[a]Nests deserted due to disturbance by the searching crew were not included in calculations of nest success.

brood count was only 21; thus presumably not more than 6 broods were produced by the second nesting attempt. Since nest success from the late nesting effort was 55%, 11 (65%) of the 17 remaining hens must have renested. Age classes among the 21 broods found during counts on 21–23 July were used to check accuracy of these calculations. Since 15 broods should have come from the early nesting effort, they should have been of age class Ic or older, and the remaining 6 should have been in classes Ia and Ib. The actual count of broods was five IIa, four IIb, and six IIc, plus two Ia and four Ib.

Nest data for the entire area showed that, for first attempts, 115 hens produced 54 broods. Of the 61 remaining hens, 65% produced 22 broods. Total production including renesting was 76 broods and thus the adjusted nest success for 115 hens was 66%.

This adjusted nest success was considerably higher than the uncorrected nest success of 50%, and probably represented a value closer to the truth. Canvasback nest success adjusted for renesting in the Minnedosa area for other years of the study showed a 24% increase over the initial data which represents the effect of renesting (Table 17).

Nest Losses

Predation accounted for 86% of the nest losses and flooding, desertion, and burning for the rest (Table 18). Raccoons destroyed 64% of the nests lost to predators.

During the 12-year period, 547 nests were observed without the hens being flushed. Inasmuch as these nests were not checked until after the eggs had hatched, no in-

Table 16. *Nest success of canvasbacks by areas in the Minnedosa District, 1963–72.*

Year	Area											
	Minnedosa–Shoal Lake			South of Minnedosa			Minnedosa–Strathclair			Strathclair–Shoal Lake		
	Nest (no.)	Success (%)	Destroyed by raccoon (%)	Nest (no.)	Success (%)	Destroyed by raccoon (%)	Nest (no.)	Success (%)	Destroyed by raccoon (%)	Nest (no.)	Success (%)	Destroyed by raccoon (%)
1963	180	45	57	116	43	41	29	38	9	35	57	7
1964	156	57	47	111	57	33	23	43	9	22	72	5
1965	198	33	74	148	28	61	19	26	7	31	61	6
1966	173	50	40	141	49	34	12	58	0	20	50	6
1967	179	36	69	134	28	56	20	45	9	25	68	4
1968	152	21	70	98	7	60	25	28	7	29	62	3
1969	162	62	33	108	56	26	22	50	5	32	88	2
1970	141	55	35	101	46	32	9	78	1	31	71	2
1971	153	59	29	112	57	26	10	70	1	31	61	2
1972	140	48	47	115	44	43	8	50	3	17	76	1
Mean	163	46	50	118	42	41	18	49	5	27	67	4

Table 17. *Percent nest success of canvasbacks adjusted for renesting in the Minnesoda study area, 1961–72.*

Year	Initial success	Adjusted success
1961	32	–
1962	46	–
1963	45	60
1964	57	70
1965	33	47
1966	50	66
1967	36	50
1968	21	25
1969	62	70
1970	55	62
1971	59	70
1972	48	66
Mean	45	59

Table 18. *Probable cause of canvasback nest losses in the Minnedosa study area, 1961–72.*

Cause of losses	Nests destroyed	
	No.	Percent
Raccoons	672	56
Crows and red fox[a]	184	15
Skunks	89	7
Other mammals	106	9
Flooded	72	6
Deserted	76	6
Burned	8	1
Total	1,207	100

[a]Predominantly crow predation but both crows and foxes remove eggs from nests.

vestigator disturbance occurred. Success of undisturbed nests was 50% and success of nests from which the hen was flushed at least once was 45%. Success of nests not occupied by the hen was only 28%, but some of these nests may have been deserted when found. It is apparent that flushing hens had little if any effect on overall nest success (X^2 = 3.286, $P > 0.05$).

Clutch Size

A total of 1,131 canvasback nests had completed clutches when they were found (Table 19). Clutch size for the 12-year period average 7.7 eggs and ranged from a low of 7.2 in 1970 to a high of 8.5 in 1968. Unparasitized nests (those not containing redhead eggs) contained larger canvasback clutches than did parasitized ones. Average clutch size for nests not parasitized by redheads was 8.2. The average number of redhead eggs per canvasback nest was 1.8 or 20% of the clutch. The average number of canvasback eggs laid was 8.2 in the first nesting attempts and 6.9 in renesting attempts. Clutch sizes of 497 unparasitized nests ranged from 2 to 16 eggs. Clutches larger than 12 or 13 eggs may indicate that two or more canvasbacks laid eggs in one nest.

The average number of canvasback and redhead eggs in successful canvasback nests was 9.5, whereas the number of canvasback eggs per successful nest was only 7.7. Of these, an average of 6.2 canvasback eggs hatched per nest, indicating an egg loss of 20% (Table 20).

Nest Parasitism

The percentage of canvasback nests with complete clutches that contained one or more redhead eggs averaged

Table 19. *Canvasback clutch data from the Minnedosa study area, 1961–72.*

Year	Complete clutches	Total eggs per nest			Canvasback eggs per nest	
		Canvasback	Redhead	Total	Unparasitized	Parasitized
1961	58	7.4	2.1	9.5	8.1	6.8
1962	91	7.7	1.8	9.5	8.2	7.3
1963	96	7.5	1.8	9.4	7.9	7.2
1964	108	7.6	2.0	9.6	8.6	7.0
1965	104	7.9	2.3	10.3	8.9	7.6
1966	103	8.2	1.8	10.0	8.7	7.8
1967	96	7.3	2.7	10.0	7.6	7.2
1968	80	8.5	1.4	9.9	8.8	8.0
1969	109	8.2	1.2	9.4	8.2	7.7
1970	86	7.2	1.9	9.0	7.8	6.6
1971	107	7.3	1.7[a]	9.0	7.9	6.8
1972	93	7.5	1.9	9.4	8.1	7.1
Total or mean	1,131	7.7	1.9	9.6	8.2	7.3

[a]Includes six ruddy duck eggs.

Table 20. *Mean clutch data from successful canvasback nests in the Minnedosa study area, 1961–72.*

Year	Total nests	Canvasback eggs: Total eggs in nest[a]	Canvasback eggs: No. per nest	Canvasback eggs: No. hatched per nest	Eggs lost: No.	Eggs lost: Percent
1961	29	9.9	7.6	6.8	0.8	11
1962	54	9.4	7.9	6.8	1.1	14
1963	58	8.5	6.8	5.8	1.1	15
1964	67	10.0	7.9	6.3	1.6	20
1965	60	10.0	7.9	6.0	1.9	24
1966	70	10.2	8.3	7.2	1.2	14
1967	55	9.8	7.3	5.4	1.8	25
1968	30	10.0	8.2	5.6	2.7	32
1969	77	9.4	8.3	6.5	1.8	21
1970	59	8.8	7.2	5.6	1.7	23
1971	75	8.8	7.3	5.8	1.5	21
1972	61	9.2	7.4	6.3	1.1	15
Mean	58	9.5	7.7	6.2	1.5	20

[a]Includes redhead eggs.

57 for 1961–72 (Table 21). The average number of redhead eggs in parasitized nests was 3.14. Overall average number of redhead eggs hatched in parasitized canvasback nests was 0.64.

Redheads arrived and began nesting in the Minnedosa area about 2 weeks later than canvasbacks (Appendix B). Redhead first-nesting peaks coincided with renesting efforts of canvasbacks. More canvasback renests were parasitized by redheads than first nests (paired t-test, $P < 0.05$; Table 22). There appeared to be a positive relation between levels of nest parasitism by redheads and sizes of their breeding populations.

Table 21. *Average number of redhead eggs in parasitized canvasback nests in the Minnedosa study area, 1961–72.*

Year	Percentage of nests parasitized[a]	No. redhead eggs in nests: Successful nests	Failed nests	Hatched per nest[b]
1961	53	4.5	4.0	0.5
1962	58	3.2	3.1	0.5
1963	67	2.6	3.1	0.6
1964	56	3.7	3.4	0.6
1965	70	3.0	3.6	0.6
1966	56	3.2	3.3	0.9
1967	64	3.8	5.0	0.7
1968	41	3.1	3.6	0.5
1969	42	2.8	3.0	0.5
1970	42	3.2	4.2	0.8
1971	60	3.1	3.1	0.8
1972	54	1.7	2.2	0.6
Total nests	–	1,174	946	–
Mean	57	3.1	3.5	0.6

[a]Nests that contained at least one redhead egg.

[b]These figures may be low because identification of eggs was impossible in some hatched nests.

Nesting Habitat

The number and success of canvasback nests by habitat types within the intensive study unit are presented in Table 23. Wetland sizes used in these tables are the same as those used in May habitat surveys (Tables 1–7).

Of the total canvasback nests, 94% were in wetland Types 4 and 5, and nest density was greatest in Type 4. These relations probably reflect the relative availability of suitable nest cover among the various wetland types. Nest success did not differ significantly in wetlands of Types 3, 4, and 5 ($X^2 = 0.225$, $P > 0.05$).

Of all nests, 41% occurred in wetlands of 0.2 ha or less and 65% in wetlands of 0.4 ha or less (Fig. 10). Areas of many of these wetlands were less than 0.5 ha. About 2% of the nests found were in wetlands larger than 2 ha. During

Table 22. *Redhead parasitism of canvasback nests, by nesting attempt in the Minnedosa study area, 1964–72.*

Year	First nesting: Canvasback nests parasitized (%)	First nesting: Redhead eggs/ canvasback nest	Renesting: Canvasback nests parasitized (%)	Renesting: Redhead eggs/ canvasback nest
1964	49	2.7	70	4.5
1965	41	1.3	78	2.7
1966	58	1.6	54	2.1
1967	56	2.2	74	3.4
1968	33	1.0	58	2.1
1969	48	1.3	35	1.2
1970	40	1.7	54	2.0
1971	58	1.6	68	2.2
1972	53	1.3	55	1.9
Mean	48	1.6	61	2.5

Table 23. *Number and success of canvasback nests, by pond classes, in the Minnedosa study area, 1963–72.*

Habitat classification	Nests		
	Total	No./ha	Mean success (%)
Wetland type			
1	1	T	0
3	74	0.12	40
4	653	0.64	42
5	456	0.12	41
Pond size (ha)			
0.1–0.5	487	0.62	43
0.6–1.0	281	0.42	37
1.1–2.0	188	0.18	43
2.1–5.0	206	0.10	44
5.1–10	22	0.02	32
>10	0	0.00	0
Land use type			
Cultivated land	727	0.17	40
Ungrazed grassland	155	0.25	40
Grassland pasture	143	0.20	43
Wooded pasture	60	0.52	45
Ungrazed woodland	68	2.32	53
Hayland	31	0.64	32
Nest cover type			
Cattail	542	0.02	43
Bulrush	332	0.03	42
Whitetop	180	0.01	34
Willows	29	0.04	38
Mixed	75	0.01	44
Carex	21	0.01	33
Reeds	5	0.02	50
Shoreline cover type			
Open	858	0.15	38
1/4–2/3 wooded	205	0.54	38
2/3 + wooded	121	1.04	44

the 12 years, nest success was similar in wetlands of different sizes, but nest densities were greatest in the smaller ones.

Water depths at nests ranged from 0 to 91 cm. Average water depth at successful nests was 38 cm, but was only 1.8 cm deeper than that at unsuccessful nests. Successful nests were an average of 0.9 m farther from shore than unsuccessful nests and ranged from 0 to 12.5 m from shore.

About 61% of the canvasback nests were on wetlands in cultivated land; success of these nests was only slightly below average. Nests in ponds surrounded by grazed and ungrazed grassland were also similar in density and success. Nest densities and nest success were highest in wetlands located in ungrazed woodland. A total of 72% of the nests were in wetlands with open shorelines, but nest density was greater on wooded ponds. Nests in wooded ponds were also more successful than those on more open ponds.

More nests were found in cattails than in any other cover type, but the number of nests per unit cover was higher in both willow and hardstem bulrush. During the 12 years, nest success was highest in reeds but this cover type contained less than 1% of the total nests found. Nest success in cattail and hardstem bulrush was about the same.

Brood Production

An average of 63% of the canvasback broods counted during beat-outs occurred on roadside brood counts (Table 24). High water and dense vegetation reduced observability of broods from the road in some years. Some wetlands were not observable from the road in late summer because of the height of natural vegetation or crops. Beat-out counts indicated high numbers of broods in 1963, 1964, and 1966, and low numbers in 1967, 1968, and 1972 (Table 24).

Table 24. *Canvasback broods observed by transects and beat-out counts in the Minnedosa study area, 1962–72.*

Year	Transects		Beat-out areas[a]	
	No.	No./km²	No.	No./km²
1962[b]	18	0.6	13	1.7
1963	32	0.6	15	1.9
1964	91	1.8	17	2.2
1965	43	0.9	12	0.8
1966	71	1.4	21	2.7
1967[c]	24	0.5	5	0.5
1968[c]	6	0.1	2	0.2
1969[c]	40	0.8	9	0.9
1970[c]	24	0.5	10	1.0
1971[c]	28	0.5	15	1.5
1972[c]	24	0.5	2	0.2
Mean		0.7		1.3

[a]"Beat-out counts" see waterfowl census techniques, Stoudt 1971.
[b]Only 28.49 km² surveyed in 1962.
[c]10.36 km²; all previous years 7.77 km².

Brood Size

Mean brood sizes were based on observations of 1,832 canvasback broods, including those with redheads (Table 25). These data included only broods in which all ducklings were believed to have been seen. Broods were recorded by three major classes (I, II, III) to increase sample size. Brood size declined from an average of 5.9 Class I ducklings to 5.3 Class III ducklings as the breeding season progressed. Brood sizes were largest in 1965, 1966, and 1972 and smallest in 1963, 1967, and 1968. The number of observations in Class III broods was small because the fieldwork ended on 1 August, and broods had begun to break up.

Fig. 10. A small wetland highly preferred by nesting female canvasbacks in the Minnedosa study area.

Mixed Broods

It is not always possible to identify redhead ducklings in canvasback broods, especially when the birds are young or the light is poor. Broods in which the number of redhead ducklings was not accurately determined were omitted from final tabulations. However, numbers of redhead ducklings per canvasback brood (Table 26) are probably conservative. Variation between numbers of redheads in Class I and II broods is probably a result of some redheads in the younger age classes being overlooked. The most significant feature of the data for most years is the close relation between the number of redhead ducklings per canvasback brood and the density of redhead breeding pairs for corresponding years.

Brood counts indicated that more canvasback nests were parasitized by redheads during the middle and late portions of the nesting season than during the early portion (Table 27). Wide variation in numbers of redhead ducklings from nests hatched after 16 July might have been due to the small sample size for that period.

Juvenile Mortality

Brood sizes of Class II ducklings were used to determine juvenile mortality (Table 28) because canvasback broods of Class III usually separated into two or more groups and were difficult to recognize as a unit. Inasmuch as the difference in mean size between Class II and Class III broods (minus redheads) was less than 0.5 duckling (Table 25), mortality appeared to be low. Actual juvenile mortality from nestlings to fledglings is probably depicted accurately by the data of Table 28. Juvenile mortality averaged 21% during the 12-year study, although there were marked year-to-year variations. These data do not include losses of entire broods.

Table 25. *Number of ducklings observed in canvasback broods by age classes in the Minnedosa study area, 1961–72*[a]

Year	Age class[b] Class I 0–25 days	Class II 26–53 days	Class III 54–65 days	Total
1961	6.0 (33)[c]	5.5 (55)	– (2)	5.7 (90)
1962	6.0 (59)	5.5 (45)	– (0)	5.8 (104)
1963	4.5 (71)	4.9 (28)	– (0)	4.6 (99)
1964	5.8 (125)	5.7 (141)	5.6 (11)	5.7 (277)
1965	6.8 (81)	6.2 (62)	5.0 (8)	6.5 (151)
1966	6.5 (177)	5.7 (111)	6.1 (17)	6.2 (305)
1967	4.9 (79)	5.7 (41)	5.8 (6)	5.2 (126)
1968	5.2 (40)	4.5 (24)	4.0 (1)	4.9 (65)
1969	5.8 (126)	5.9 (90)	5.4 (25)	5.8 (241)
1970	5.7 (64)	5.7 (33)	– –	5.7 (98)
1971	5.5 (55)	5.4 (41)	4.1 (8)	5.3 (104)
1972	6.8 (94)	6.1 (65)	5.1 (13)	6.4 (172)
Mean and total	5.9 (1,004)	5.6 (736)	5.3 (92)	5.8 (1,832)

[a]Mean number of ducklings per brood including redheads.
[b]J. B. Gollop and W. H. Marshall, unpublished report.
[c]Number of broods.

Brood Habitat

The number of wetlands present in the latter part of July averaged 147.6/km² along roadside transects and 168.4/km² on beat-out areas (Table 29). The difference in the two values represents the number of wetlands not visible from the road. The mean loss in number of wetlands between early May and late July during the 12 years was 16% (Tables 1 and 29). Wetland loss during May to July was only 1.3% in 1969 and 1.4% in 1971.

Table 26. *Mean number of redhead ducklings in canvasback broods in the Minnedosa study area, 1962–72.*

Year	Class I Canvasback broods	Class I Redheads per brood	Class II Canvasback broods	Class II Redheads per brood
1962	59	0.3	45	0.3
1963	71	0.4	28	0.5
1964	111	0.7	141	1.0
1965	78	1.4	56	1.7
1966	148	0.6	106	0.7
1967	72	0.6	34	1.3
1968	39	0.3	23	0.3
1969	117	0.5	84	0.7
1970	58	0.3	34	0.4
1971	51	0.5	39	0.9
1972	84	0.9	61	1.4
Mean	81	0.6	59	0.8

Table 27. *Percentage of canvasback broods with redheads at hatching; and number of redhead ducklings per canvasback brood (in parentheses) in the Minnedosa study area, 1963–72.*

Year	Hatching dates 1–15 June	16–30 June	1–15 July	16–31 July
1963	19 (0.3)	32 (0.7)	35 (0.4)	8 (3.0)
1964	32 (0.5)	35 (1.0)	35 (1.0)	67 (1.0)
1965	17 (0.2)	51 (1.2)	61 (1.7)	88 (2.8)
1966	25 (0.3)	31 (0.7)	23 (0.8)	0 (0.0)
1967	8 (0.2)	33 (0.8)	43 (1.0)	0 (0.0)
1968	14 (0.2)	25 (0.4)	0 (0.0)	0 (0.0)
1969	24 (0.4)	43 (0.9)	13 (1.0)	38 (0.4)
1970	30 (0.4)	13 (0.3)	24 (0.4)	50 (0.6)
1971	8 (0.1)	64 (1.1)	33 (1.4)	0 (0.0)
1972	35 (0.7)	56 (1.8)	45 (1.1)	50 (3.5)

Table 28. *Mean mortality of canvasback ducklings (redheads excluded) from hatching to Class II broods in the Minnedosa study area, 1961–72.*

Year	Eggs hatched per nest	Class I Ducklings per brood	Class I Loss, hatching to Class I (%)	Class II Ducklings per brood	Class II Loss, hatching to Class II (%)
1961	6.8	5.5	18.7	5.1	24.4
1962	6.8	5.6	18.2	5.0	26.1
1963	5.8	4.1	29.3	4.4	23.7
1964	6.3	5.1	18.9	4.7	25.5
1965	6.0	5.5	9.4	4.5	25.2
1966	7.2	5.8	18.5	5.0	30.6
1967	5.4	4.4	19.4	4.4	19.6
1968	5.6	4.9	11.4	4.2	24.5
1969	6.5	5.2	19.5	5.2	19.6
1970	5.6	5.4	2.5	5.2	5.7
1971	5.8	4.9	15.5	4.6	20.4
1972	6.3	5.8	7.8	5.7	10.0
Mean	6.2	5.2	1.0	4.8	21.5

Table 29. *Number and area of wetlands with water in mid-July in the Minnedosa study area, 1962–72.*

	Roadside transects		Beat-out areas	
Year[a]	No.	Km²	No.	Km²
1962			261	10.0
1963			275	35.5
1964	735	14.3	197	25.5
1965	1,212	23.6	301	38.6
1966	1,130	22.0	214	27.4
1967	785	15.1	141	18.1
1968	760	14.7	102	13.1
1969	1,540	29.7	308	29.7
1970	1,430	27.8	286	27.8
1971	1,450	28.2	290	28.2
1972	1,130	22.0	226	21.6
Mean	–	22.0	–	25.1

[a]No data for roadside transects in 1962 or 1963.

Brood use per hectare of wetland was greatest on Type 5 wetlands (Table 30). Of all canvasback broods observed, 82% were on Type 5 wetlands; only 2% were seen on Type 3 and none on Type 1. The heavy use of Type 5 wetlands by canvasback hens with broods indicates the need for this permanent type of wetland in canvasback breeding habitat.

Wetlands larger than 0.4 ha were used most extensively by hens with broods (Table 30) – as they were by breeding pairs (Table 10). Wetlands 0.2 ha or smaller were used least for brood rearing but heavily for nesting (Fig. 11). Because brood use was greater on the larger wetlands it was also greater on the deeper wetlands (Table 30).

Hens with broods appeared to select wetlands located in wooded pastures but the pattern was not consistent (Table 30). In some years brood use was greatest in open pasture. The rather inconsistent rate of brood use of various land use types between years suggests that factors other than land use may be important in determining wetland preference for canvasback hens with broods. However, when the data were summarized by major land use types (Table 30), use of wetlands in pasture was heaviest. Although 85% of all broods were found on wetlands with less than one-third of their shoreline wooded, brood densities were higher on half-wooded wetlands (Table 30).

Canvasback broods most often used wetlands with less than one-third of the water area covered with emergent aquatic vegetation (Fig. 12, Table 30). If Class Ia broods were omitted from the analysis, use of the more open wetlands would be the greater. Brood use was greatest in wetlands that contained a mixture of cattail and hardstem bulrush (Table 30).

Table 30. *Use of different habitat types by canvasback broods in the Minnedosa study area, 1962–72.*

	Broods	Habitat types
Habitat classification	No./ha of water	Mean size ha/year[a]
Wetland type		
1	0.00	2.0
3	0.01	16.6
4	0.10	23.1
5	0.12	72.9
Pond size (ha)		
0.1–0.5	0.03	13.4
0.6–1.0	0.09	12.2
1.1–2.0	0.13	21.1
2.1–4.0	0.12	51.4
>4	0.15	16.6
Land use type		
Grassland pasture	0.21	11.3
Wooded pasture	0.21	4.1
Ungrazed woodland	0.12	3.2
Ungrazed grassland	0.11	7.3
Grain crops	0.13	53.9
Summer fallow	0.11	30.4
Hay crops	0.06	4.1
Pasture	0.17	15.4
Idle land	0.10	11.0
Cultivated	0.11	84.2
Hayland	0.06	4.1
Shore cover type		
Open	0.11	101.3
Half-wooded	0.12	10.1
Wooded	0.07	3.2
Percent of emergent vegetation		
0–10	0.15	50.6
11–33	0.15	37.3
34–66	0.04	13.8
>66	0.02	13.4
Emergent vegetation species		
Bulrush	0.12	29.6
Mixed	0.10	46.6
Carex	0.03	2.4
Cattail	0.14	10.9
Open	0.16	7.3
Whitetop	0.08	17.8
Pond depth (cm)		
1–30	0.01	10.5
30–60	0.10	27.1
>60	0.14	76.1

[a]For wetland type, "mean (ha/year)" refers to mean hectares of water; for land use and shore cover type, the value refers to mean hectares per year of the land use or above cover type specified.

Productivity

Average annual production of canvasback ducklings from 1961 to 1972 was 9.7/km² (Table 31), including adjusted data on nest success and clutch size. Production was below average in 7 of the 12 years. Production was poor in 1961 and 1962 because the breeding population was low and nesting success was poor, and in 1967, 1970, and 1972 be-

Fig. 11. Canvasback brood in a small wetland in the Minnedosa study area.

cause the number of breeding pairs was small. Nest success was poor in 1965 but production was only slightly below average because the breeding population was high. The poorest production – in 1968 – was caused mainly by poor nesting success. Production was highest in 1964, when the breeding population and nesting success were both high. Good production in 1963, 1966, and 1969 was mainly a result of a high rate of successful nesting.

Dzubin's (1952:73, 1955:88) reports on the Roseneath study area permit a comparison of brood data from certain other years. The numbers of broods found averaged 3.39 ± 0.45/km² during 1949–55, as compared with 1.86 ± 0.77 on the same area in 1962–67. Although the number of broods produced were 0.54/km² lower during 1962–67, these differences were not significant ($t = 1.46$, $P > 0.05$). Broods per nesting pair during 1949–55, however, were 0.88 ± 0.24 as calculated from Dzubin's data (1952:73, 1955:88) compared with 0.48 ± 0.14 brood per pair on the same area from 1962 to 1967. These results showed significantly lower productivity ($t = 2.29$, $P < 0.10$). Productivity (broods per pair) on three study areas from 1961 to 1967 was 0.7 for Redvers, Saskatchewan (Stoudt 1971), 0.6 for Lousana, Alberta (Smith 1971), and 0.4 for Minnedosa, Manitoba (present study). The lower rate of production at Minnedosa in recent years can probably be attributed to raccoon predation.

Reproductive success of canvasbacks on the intensive study area was measured by nest studies and the number of pairs per brood. Average productivity was 37% by the pair-brood method and 53.3% by the nest success method (Table 32). The difference between the two may be a measure of brood movement off the roadside transects, mortality of entire broods, or failure of some hens to nest.

Estimated annual production of canvasback ducklings

Fig. 12. High-quality canvasback wetland in the Minnedosa study area.

contributing to the fall flight from the study area (estimates calculated by multiplying total pairs by hen success and ducklings per brood) averaged 7.7/km^2 (Table 33).

Summary and Discussion

Breeding Populations

Breeding populations of canvasbacks increased from lows during the 1958–62 drought to a high in 1965. In 1966 a downward trend began that continued through 1972. This decrease represented a serious population trend on one of the better segments of canvasback habitat in North America (Kiel et al. 1972).

The gradual increase in breeding populations from 1961 to 1963 may have been due to improved habitat conditions, the closed hunting season on canvasbacks in the United States from 1960 to 1964 (Geis and Crissey 1969), and high productivity of hens in 1962 and 1963, or a combination of all of these variables. Stabilized canvasback population levels from 1963 to 1965 may have been a result of improvement of canvasback habitat throughout the Canadian prairie wetland area. Although the true value is difficult to determine, the Minnedosa area may have approached maximum carrying capacity for canvasbacks at 3.9 or 4.3 pairs/km^2.

The decrease in breeding pairs in 1966 may have been caused by poor production in 1965. Further reduction in the breeding population in 1967, however, is difficult to explain because of the excellent production in 1966 and because habitat conditions appeared to be adequate. The reduction in breeding pairs in 1967 was possibly due to a decrease in acreage of nest cover brought about by exten-

Table 31. *Canvasback production in the Minnedosa study area, 1961–72.*

Year	Pairs per km²	Nests hatched per km²	Eggs hatched	Nest success (%)	Ducklings per km²
1961	2.3	0.7	6.8	32	5.0
1962	2.7	1.4	6.8	51	9.3
1963	3.8	2.3	5.8	60	13.1
1964	3.9	2.7	6.3	70	17.4
1965	4.1	1.9	6.0	47	11.6
1966	3.1	2.1	7.2	66	14.7
1967	2.7	1.3	5.4	50	7.3
1968[a]	2.9	0.3	6.2	9	1.5
1969	2.6	1.8	6.5	70	11.6
1970	2.1	1.3	5.6	62	7.3
1971	2.4	1.7	5.8	70	9.7
1972	2.2	1.4	6.3	66	8.9
Mean	2.9	1.6	6.2	54	9.7

[a]Only nest data collected south of Minnedosa were used in 1968 because of wide divergence of data obtained from nests west of Minnedosa.

sive burning in fall 1966 (Fig. 13). Many hectares of cattail and bulrush nesting cover were burned over. Harvest regulations on canvasbacks were also relaxed during this period in all four waterfowl flyways (Reeves and Carney 1976).

Stewart et al. (1958:337), who summarized canvasback breeding population densities from aerial survey data (1953–56), found that populations on the Canadian prairies ranged from 0.5 to 1.0 bird/km². Higher populations were found on Hay Lakes, Old Crow Flats, and Athabaska Delta in the north. From these data it appears that canvasback breeding populations were higher in the Minnedosa area than in other breeding areas that were surveyed. During years of severe drought this area consistently had higher breeding populations than did most prairie and parkland regions.

It appears that the 1963–65 canvasback population on the Roseneath area was as high or higher than at any previously recorded period (Dzubin 1952, 1955). By 1970 it

Table 32. *Reproductive success of canvasbacks by pair-brood and nest success methods on the Minnedosa study area, 1963–72.*

Year	Total pairs[a]	Total broods[a]	Broods per pair (%)	Adjusted nest success (%)
1963	30	15	50	57
1964	32	20	63	70
1965	36	12	33	40
1966	32	21	66	65
1967	34	5	15	39
1968	29	2	7	8
1969	28	12	43	63
1970	26	10	38	57
1971	32	15	47	68
1972	24	2	8	66
Mean	30.3	11.4	37.0	53.3

[a]Beat-out census.

Table 33. *Total estimated canvasback production in the Minnedosa District, 1961–72.*

Year	Total pairs per km²	Hen success[a] (%)	Brood production per km²	Ducklings per brood	Total ducklings per km²
1961	2.3	32	0.7	5.1	3.9
1962	2.7	51	1.4	5.0	7.0
1963	3.8	60	2.3	4.4	10.0
1964	3.9	70	2.7	4.7	12.7
1965	4.1	47	1.9	4.5	8.5
1966	3.1	66	2.1	5.0	10.4
1967	2.7	50	1.3	4.4	5.8
1968	2.9	25	0.7	4.2	3.1
1969	2.6	70	1.7	5.2	8.9
1970	2.1	62	1.3	5.2	7.0
1971	2.4	70	1.7	4.6	7.7
1972	2.2	66	1.4	5.7	8.1
Mean	2.9	56	1.6	4.8	7.7

[a]Includes nest data from Shoal Lake area.

Fig. 13. Spring burn on a canvasback wetland in the Minnedosa study area.

had decreased to the 1953–55 low level. The population on the Minnedosa area was lowest in 1955, when the number of wetlands on the Canadian prairies was high. At that time peak canvasback populations were recorded on the Redvers and Lousana study areas in Saskatchewan and Alberta (Smith 1971; Stoudt 1971).

Habitat use by breeding pairs is dependent on many factors, including size and depth of wetlands; adjacent land use; and amount, distribution, and species of emergent vegetation in wetlands. These factors may also influence the quality and quantity of food present in wetlands. Food may be the single most important factor influencing the use of wetlands by canvasbacks. Bartonek and Hickey (1969*a*) found that adult canvasbacks fed heavily on sago pondweed, caddisfly larvae, and pond snails during the breeding season.

Nesting Parameters

Although there were annual differences in nest success between various wetland size classes, means for the 12-year period were consistent. Observations in the field indicated that canvasback hens possibly sought the seclusion of smaller wetlands for nesting to avoid redheads that continually harassed them. Often two or more canvasback hens nested in the same small pond, which might indicate a behavioral strategy for avoiding redheads or predators. Dzubin (1955) and Olson (1964) also reported a preference by canvasback females for small nesting wetlands, as did Stoudt (1971) on the Redvers study area in Saskatchewan.

The percentage of canvasback nests in wetlands of 0.4 ha or less was highest during early nesting attempts. Larger wetlands were used during renesting attempts in June. Hens

Fig. 14. Canvasback nest in hardstem bulrush in the Minnedosa study area.

Fig. 15. Canvasback nests stranded by drought in the Minnedosa study area.

thus exhibited the normal tendency to nest in small wetlands when they first returned to the nesting ground, but after losing their first nests they sought sites in larger wetlands for their second attempts. This tendency was most pronounced in years when water levels receded rapidly and smaller wetlands began to dry up, but was not an important factor in normal years, when wetlands bordered with cattail or bulrush usually held water throughout the nesting season (Fig. 14).

As the season progressed each year, canvasback hens tended to nest in the more permanent wetlands where water levels were more stable. In dry years such as 1961, 1962, and 1967, rapidly receding water levels in Type 3 wetlands allowed increased predation. Flooding from excessive rainfall usually affected Type 1 and 3 wetlands more than more permanent wetlands, resulting in increased nest desertion. There was no evidence that nests over deep water were more secure from raccoons than those over shallow water. Nests over shallow water, however, were more apt to become stranded before hatching, making them more vulnerable to crows, magpies, skunks, fox, and other upland predators.

The success of nests in wooded wetlands seemed unusual in an area where raccoons were abundant. The estimated number of nests per hectare in ungrazed woodland may be high as a result of the small sample recorded on the beat-out census. Most raccoons in the area seemed to live in abandoned farm buildings, granaries, and heavy marsh cover (Cowan 1973).

There are several possible reasons for the low use of whitetop areas, in contrast to the abundance of this vegetation type. When weather and water levels permitted, most whitetop was harvested for hay or burned each fall because it generally occurred in wetlands that dried up by July or August. Generally, most whitetop was green and too short for use as nest cover for the first canvasback nesting attempt. Lower nest success in this cover type was mainly due to predation on nests that were stranded after the shallow whitetop wetlands dried up. Nests in willow clumps also seemed vulnerable, probably because of their conspicuousness. Nests in willows were particularly prone to predation by raccoons and crows. The apparent low use of the "mixed" cover type was due to the fact that although many wetlands were classified as mixed, the nests were usually in a single cover type.

Factors affecting waterfowl nest success are numerous. Canvasback nest destruction or desertion is usually caused by predators, parasitism by redheads, weather, or agricultural operations. Prolonged cold weather may inhibit production of predator food and cause increased predation on early nesting ducks. Dry weather may encourage burning of pond edges, which destroys both nest cover and nests. Long periods of rainy weather may save some nests by preventing farmers from burning nest cover. Extended drought during the nesting season may delay or reduce initial nesting efforts and seriously curtail renesting attempts. Drought may also cause a rapid lowering of water levels, stranding nests on dry ground and increasing their vulnerability to predation (Fig. 15).

Freezing weather often occurred after early nesting had begun. Most wetlands iced over on 22 May 1963 and some canvasback hens deserted nests where incubation had not begun. In 1965, some canvasbacks abandoned their nests during 24–27 May. From 24 to 26 May, 2 days of rain were followed by 1 day of snow and high winds; and on 27 May the temperature dropped to nearly $-6°$ C, nests were ringed with snow, and some wetlands froze over.

On 30 April 1966, 45.7 cm of snow and a temperature of $-17°$ C halted migration, and most canvasbacks moved to the larger lakes. All wetlands and small lakes froze over.

On 1 May 1967, a severe blizzard occurred in North Dakota but little snow fell at Minnedosa. Nearly all wetlands on the study area were still frozen over on 3 May and canvasback migration and nesting were considerably delayed. In general, production was best during years when water levels remained fairly constant and no extremely cold weather occurred after incubation had begun.

Nesting canvasbacks, along with mallards and pintails, began searching for nest sites soon after arriving on the nesting grounds. H. A. Hochbaum (personal communication) reported that canvasbacks arrived at the Delta Waterfowl Research Station, south central Manitoba, on 24 April in 1965. During the night of 25–26 April, large numbers of many species of ducks arrived, including many canvasbacks. The Delta Station lies 113 km east of the Minnedosa study area and the phenology at Delta differs by a few days from that at Minnedosa. On 30 April 1965, canvasback hens were seen searching for nest sites on the study area and the first egg was laid on 1 May. In 1966, all wetlands and even large lakes were frozen on 1 May but by 9 May the sighting of canvasback hens searching for nest sites was common. The first egg was laid on 6 May.

Hochbaum (1944:62) stated that hen canvasbacks select the breeding territory. This observation was corroborated during the present study. Hens selected the nest wetland and drakes either waited on the wetland or flew to nearby wetlands to join other drakes and pairs. During nest searching and early stages of egg laying, males usually waited near the hens. Many nests were found after a lone drake was observed on a wetland, and the hen was flushed from the cover. If the hen was merely searching for a nest site but not actually laying eggs or sitting on the nest, disturbance usually caused her to abandon further use of that wetland. Searching for nest sites took several days, during which the hens were wary and easily frightened.

Nest success was poor in 1961, 1965, 1967, and 1968, and though most of the nests were actually destroyed by predators, weather played an important role in each of those years. Most nest abandonment was caused by weather but amounted to less than 15% of total nest failures. Stable or gradually lowering water levels like those in 1968, 1970, and 1971 were usually conducive to good nesting success for overwater nesters. However, burning of pothole edges and predation upset this generality in 1968. Abruptly rising water levels in July 1965 caused an appreciable nest loss because of an extensive late-nesting effort brought about by loss of early nests resulting from low temperatures and snow in May.

Extreme rainfall affects pond levels and nest success. On 20 July 1965, more than 15.2 cm of rain fell during a few hours. Wetlands filled and spilled over, flooding many overwater nests of redheads, ruddy ducks, and late-nesting canvasbacks. Although flooding occurred in July 1969, early nests were very successful; consequently, the effect of the flooding on total nest success in that year was not severe.

Years in which rainfall was lacking during the nesting season were also poor for duck production. In May and June 1967, for example, wetland levels dropped rapidly and much overwater nest cover became unsuitable. Predators took a heavy toll of nests stranded on dry ground, and renesting was greatly inhibited. Olson (1964) also reported poor nest success and high predation rates during drought years.

Both drought and excessive rainfall appeared to have disastrous effects on nesting. Drought was the most serious, however, as it usually had the longer and more critical effects. In many instances when wetlands became dry, they were plowed and permanent drains established. Even where no drainage occurred, cultivation of a dry wetland temporarily destroyed aquatic and semi-aquatic vegetation (Fig. 16).

Heavy predation on early nests occurred during the 1961 drought. No strong renesting effort ensued because of dry weather and resultant rapid lowering of water levels. Overwater nest cover was rapidly made untenable and renesting was curtailed. In 1965, a severe cold front moved into the area on 23 May. Rain was followed by snow and subfreezing weather. Many nests were deserted and in some nests eggs were inadvertently buried by hens trying to keep nests and eggs above rising water levels. Nest data indicated that 19% of the first nesting attempts succeeded and, although 47% of the renests also succeeded, total success was below average for the area. Precipitation during the nesting season in 1967 was the lowest for the 12-year period, water levels receded, canvasback nests were stranded, and predation was severe. The weather was cool enough to stimulate a good renesting effort but nest success was poorer than for the first effort. Renests are usually more successful than first nests but this was not true in 1967. Although overwater nest cover appeared to be adequate for the number of canvasback pairs present on the area, nest success (including renests) was low in 1968.

Relations between nest success and habitat types were often difficult to determine. Nest success for any species of waterfowl is in part related to the species composition and density of predators and size of their home ranges. If a nest was located in a comparatively predator-free area and was not subjected to severe weather or farming operations, chances for its success were high, irrespective of the quality of the cover. The local influence of predation on nests was believed to be one of the main reasons for the variable use of ponds by broods, even though habitat conditions remained the same. To accurately assess the relative value of various habitat types, one would need a precise estimate of predator populations and size of their home ranges, along with other basic information.

When raccoons became more common, overwater nest success decreased. Numbers of raccoon pelts received by the Hudson Bay Company in Winnipeg, Manitoba, increased from 65 during the 1953–54 season to 146 in 1954–55; by 1960–61 the number had risen to 871 (E. G. Bossenmaier, personal communication). In 1959, Olson

Fig. 16. Wetland drainage and fall plowing in the Minnedosa study area.

(1964:36) reported a 10% success rate for 67 canvasback nests. It was 37% in 1960 and 19% in 1961. Drought contributed to the rate of nest destruction in 1959 and 1960 because nests were stranded on dry ground before hatching, which rendered them available to all upland predators, including raccoons.

The 1968 nesting season provided some noteworthy information on predator adaptability. As the nesting season progressed, a combination of receding water levels and extensive burning contributed to a greater-than-normal toll by predators. Increased predation also occurred on other species of upland nesting ducks, indicating a shortage of predator food. This shortage was emphasized by the fact that certain predators such as red fox, skunks, and feral cats, which normally do not enter the water while hunting, were wading in the water more than 30 cm deep to search for overwater nests. Raccoons were also more destructive than ever and many wetlands were so thoroughly searched by these predators that not a single intact duck, coot, or blackbird nest could be found. Data from 98 nests found in 1968 on the intensive study area indicated nest success of only 8%, the lowest ever recorded for canvasbacks.

Nest studies were also conducted west of Minnedosa for a distance of about 64 km. Raccoon populations appeared to be lower west of the Minnedosa River Valley and less burning was done in that area. Both of these deterrents to nest success diminished consistently farther away from the river valley. Canvasback nest success apparently reflected this trend in 1968. Eggs hatched in only 7% of the nests south of Minnedosa, 40% between Basswood and Newdale, and 62% in the vicinity of Shoal Lake.

Basswood, Newdale, and Shoal Lake are 16, 32, and 64 km northwest of Minnedosa, respectively. This disparity between nest success south of Minnedosa and that northwest

of Minnedosa was not limited to 1968 but was observed in other years as well. Field surveys and related observations suggested that raccoon populations were higher adjacent to the Minnedosa River and more wetlands and abandoned farm buildings east of the river might have provided food and shelter for raccoons.

Canvasback nest success (unadjusted for renesting) on the Redvers study area averaged 70% (Stoudt 1971) compared with 45% in the present study. Of the nest failures at Redvers in 1963, 93% were due to flooding. The wide disparity of nest success between Redvers and Minnedosa for other years perhaps can be attributed to the relative abundance of raccoons in the Minnedosa area. Other limiting factors appeared to be about equal on the two areas. Crows were not generally serious predators on canvasback nests, except during periods of rapidly receding water levels.

The percentage of canvasback nests destroyed by raccoons varied to some extent according to weather conditions. It appeared to be high in wet years and low in dry years. During dry years when wetland levels receded rapidly, many overwater nests were stranded before hatching and were vulnerable to skunks, crows, fox, and other predators. Nest losses for most species were high in 1968 because spring burning of nest cover was extensive and water levels were low and receding, increasing the vulnerability of overwater nests to predation. During the 12-year study, nest success was poorest in 1968 but best in 1969. Probable reasons for good nest success in 1969 were a decrease in numbers of red fox and raccoons, abundant predator food, and abundant upland cover that provided habitat for other nesting birds and for mice, both of which were buffer foods for predators.

Olson (1964) found that canvasback clutch sizes in southwestern Manitoba ranged from 9.7 to 10.1 for 53 complete clutches found during 1959–61. These clutches included redhead eggs. The number of canvasback eggs per clutch ranged from 6.7 to 8.5 and averaged 7.6 during the 3-year period of Olson's study. This number is slightly less than the 1961–71 mean of 7.7 at Minnedosa.

Clutch size averaged 8.3 eggs for 207 canvasback nests (1952–70) on the Redvers study area in southeastern Saskatchewan (J. H. Stoudt, unpublished data). Mean clutch size was lowest (7.9) in 1967 and highest (8.7) in 1958. During the 18-year period, the mean number of redhead eggs per canvasback nest was 0.2; thus the mean clutch size for canvasback eggs was 8.0. The slightly lower mean clutch size at Minnedosa may have been due to redhead parasitism, which sometimes caused canvasback eggs to be rolled out of the nest. Erickson (1948) found a difference of 2.2 eggs between parasitized and unparasitized nests, whereas at Minnedosa the difference was slightly less than 1.0 egg.

Erickson (1948) found an average clutch size of 9.9 in unparasitized canvasback nests and 7.7 in parasitized nests in southeastern Oregon. Weller (1959) found that the average number of redhead eggs per parasitized nest ranged from 4.2 to 6.5 in 48 canvasback nests on the Delta Marsh in Manitoba. Olson (1964) stressed the importance of parasitism as a means by which redheads were able to compete with canvasbacks and increase their numbers at the expense of canvasbacks. He stated, "Increased productivity is greatest where redhead numbers are small in comparison to their host species, as in pothole habitats. Here redhead production may be increased two-fold by their parasitic habit." Olson also wrote, ". . . drainage tends to increase the average size of the remaining wetlands even though decreasing the total amount of breeding habitat. Where this occurs the remaining nesting cover for both species is in the larger areas, which contain proportionally more redheads, and the result appears to be decreased canvasback production."

Larger clutch sizes of early nests were probably due in part to fewer eggs laid by renesting hens and more eggs rolled out of nests by redheads when parasitism was more prevalent. On Delta Marsh, Weller (1959) found that redhead parasitism decreased as the season progressed. This was not true on the Minnedosa study area, and the difference might be related to differences in habitat between the large marsh and the pothole area. At Minnedosa, redhead parasitism was considerably greater during the later canvasback nesting effort. The lower clutch size for renesting attempts illustrated one important reason why production from renesting never equaled a successful initial nesting effort.

Broods

Brood use of various habitat types was probably more closely related to availability of food and escape cover than to other factors. Escape cover may have been related to both emergent vegetation and water depth. For example, a small wetland had to be deep to allow escape by diving, and thus water depth may have been more important than abundance of emergent vegetation. Higher use of large, deep wetlands was probably due to type and abundance of food available as well as the safety of deep water.

Possibly the heavy use of wetlands in pasture was the result of high fertility and resultant high production of plant food and invertebrates. One pasture wetland on the study area that was favored by broods and intensively studied by Bartonek (1968) had a heavy growth of sago pondweed and an abundance of invertebrates. Both are important foods of ducklings (Bartonek and Hickey 1969*b*). The lower-than-average use of wetlands in ungrazed grasslands was probably a result of a large proportion of these areas being adjacent to a road where vehicle traffic may have been a deterrent to broods.

Most canvasbacks fed in open water. Stands of hardstem bulrush were relatively easy for broods to move through and probably provided better resting and escape cover than did dense stands of cattail and whitetop. Wetlands devoid of emergent vegetation were frequently used by canvasback

broods if adequate food was present, if open spots were available along the shore where broods could roost without being disturbed, and if water was deep enough to allow escape by diving.

The annual variation in brood use suggests that the species of emergent vegetation may not be as important as the percentage of water surface covered with emergents. The use of bulrush and cattail wetlands appeared to be important but most of these wetlands were less than one-third vegetated. There may be a positive relation between food production for canvasbacks and emergent cover. The entire subject of brood use of various habitat types must be further investigated to provide more specific information, especially about the relative abundance of various species of aquatic invertebrates.

Annual Production

The number of juvenile ducks in the fall flight is obviously less than the number of eggs hatched; therefore, brood surveys are essential for research and management. Observations along roadside transects yielded reliable trend data for canvasbacks, but beat-out surveys were necessary for a more precise determination of production per unit of area. An average of 60% of canvasback broods counted during beat-out surveys were found within the 0.4-km roadside transect. A visibility rate of 68% was found on the Redvers study area from 1952 to 1958 where the roadside transect was 0.2 km wide (Stoudt 1959:80).

Mean brood sizes were average in 1961, 1962, 1964, 1969, and 1971; above average in 1965 and 1966 (probably because average clutch sizes were large); and small in 1963 and 1967 (probably because clutch sizes were small). The fact that the average size of Class I broods in 1967 was considerably below the mean, whereas that of Class II broods was above the mean, is a strong indication that some of the early broods died soon after hatching. However, the mean size of Class I canvasback broods in most years followed the same trend as the mean number of canvasback eggs hatched per clutch.

Except in 1966, both the frequency and number of redhead ducklings per canvasback brood increased as the season progressed. These data parallel nest data that show that parasitism by redheads was greater during the renesting effort. Brood data from older age classes, especially those of Class III, were often unreliable because of the tendency of redhead ducklings in this age class to separate from broods. This is even more prevalent when broods are deserted by the hen.

Juvenile mortality in diving duck broods in the Minnedosa area probably varied with the amount of time they spent on land, either traveling between wetlands or resting on shore. Canvasbacks were vulnerable to many upland predators. Hens and broods spent many of the daylight hours sleeping on water or in the pseudo-sleeping attitude described by Cornwell and Bartonek (1963), but some broods were observed in open areas on sand bars or mud flats. If these locations were near cover, predation was probable and was actually observed in the present study. Overland travel, which might have been in search of food, as a result of disturbance by man, machinery, or predators, or merely as a result of the propensity of hens to change wetlands, was common. On 21 July 1961, three canvasback broods were observed on one wetland. Two of the broods spent 80% of this time on open water but the third hen took her brood across a gravel road to another wetland and returned later.

During wet years when July water levels were high and wetlands numerous, overland travel between wetlands was frequent and comparatively safe. In dry years such as 1961, 1967, and 1968, wetlands were low and less numerous and travel between them was farther and more hazardous.

In 1967, there was wide disparity between nest success and pair-brood data. Broods were so scarce that none were found on aerial flights outside the beat-out areas and roadside transects. Several broods from nests known to have hatched later disappeared from brood wetlands, and repeated attempts to relocate them were unsuccessful. Brood movement between wetlands in 1967 was probably in response to low water. Whatever the reason, increased mobility of broods could easily have contributed to a higher-than-normal juvenile mortality. Another factor that could have contributed to the loss of ducklings and entire broods was the frequency of smaller broods.

Juvenile mortality for 1963 seemed abnormally low and the number of eggs that hatched might have been underestimated. Some nests were flooded after hatching but before they were checked. The number of eggs that hatched in some of these nests might have been higher than estimated. Mortality in 1970 was low, probably because water levels were stable and brood movement negligible.

Poor production in 1961, 1967, and 1968 was a result of a combination of low breeding populations and poor nest success. Production in 1963, 1964, and 1966 was good primarily because average breeding populations were large and nest success was higher than average. Good production in 1969 was mainly a result of excellent nest success. In general, brood mortality had less effect on total production than did nest success. After canvasback broods move from a small nesting pond to a larger brood pond, broods are comparatively safe from most predators.

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Appendix A

Common and Scientific Names of Plants and Animals

Common name	Scientific name
Plants[a]	
Barley	*Hordeum vulgare*
Beaked hazelnut	*Corylus cornuta*
Bur oak	*Quercus macrocarpa*
Chokecherry	*Prunus virginiana*
Common bladderwort	*Utricularia vulgaris*
Common cattail	*Typha latifolia*
Common duckweed	*Lemna minor*
Common watermilfoil	*Myriophyllum exalbescens*
Dandelion	*Taraxacum* spp.
Hardstem bulrush	*Scirpus acutus*
Mannagrass	*Glyceria* spp.
Muskgrass	*Chara* spp.
Oat	*Avena sativa*
Pincherry	*Prunus pennsylvanica*
Quaking aspen	*Populus tremuloides*
Rapeseed	*Brassica napus*
Red osier dogwood	*Cornus stolonifera*
Reeds	*Phragmites communis*
Rushes	*Juncus* spp.
Sago pondweed	*Potamogeton pectinatus*
Saskatoon berry	*Amelanchier alnifolia*
Sedges	*Carex* spp.
Silverberry	*Elaeagnus commutata*
Softstem bulrush	*Scirpus validus*
Spikerush	*Eleocharis* spp.
Star duckweed	*Lemna trisulca*
Waterparsnip	*Sium suave*
Western waterplantain	*Alisma triviale*
Wheat	*Triticum aestivum*
Whitetop	*Fluminia festucacea*
Willow	*Salix* spp.
Winter rapeseed	*Brassica napus*
Wolfberry	*Symphoricarpos occidentalis*
Wood's rose	*Rosa woodsii*

[a]Source: Scoggan 1978.

Common name	Scientific name
Birds[b]	
American coot	*Fulica americana*
Black-billed magpie	*Pica pica*
Black tern	*Chlidonias niger*
Blue-winged teal	*Anas discors*
Canvasback	*Aythya valisineria*
Common crow	*Corvus brachyrhynchos*
Franklin's gull	*Larus pipixcan*
Great horned owl	*Bubo virginianus*
Horned grebe	*Podiceps auritus*
Killdeer	*Charadrius vociferus*
Mallard	*Anas platyrhynchos*
Marsh hawk	*Circus cyaneus*
Pied-billed grebe	*Podilymbus podiceps*
Pintail	*Anas acuta*
Redhead	*Aythya americana*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-necked pheasant	*Phasianus colchicus*
Ruddy duck	*Oxyura jamaicensis*
Sora	*Porzana carolina*
Swainson's hawk	*Buteo swainsoni*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Mammals[c]	
Badger	*Taxidea taxus*
Coyote	*Canis latrans*
Franklin's ground squirrel	*Spermophilus franklinii*
Meadow vole	*Microtus pennsylvanicus*
Mink	*Mustela vison*
Muskrat	*Ondatra zibethicus*
Raccoon	*Procyon lotor*
Red fox	*Vulpes vulpes*
Richardson's ground squirrel	*Spermophilus richardsonii*
Snowshoe hare	*Lepus americanus*
Striped skunk	*Mephitis mephitis*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
White-tailed jackrabbit	*Lepus townsendii*

[b]Source: American Ornithologists' Union 1957.

[c]Source: Banfield 1974.

Appendix B

Phenology of the Breeding Season on the Minnedosa Study Area, 1963–72 (month and day of first observations)

Indicator	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	Average date
Heavy migration of ducks	—	4/20	4/25	5/7	—	5/10	—	5/6	—	—	—
Mallard egg	4/23	4/24	4/25	4/28	4/29	4/24	4/20	4/26	4/25	4/27	4/25
Canvasback egg	4/30	4/28	5/1	5/6	5/10	5/2	4/28	5/3	4/26	5/1	5/2
Coot egg	5/11	5/11	5/13	5/15	5/15	5/12	5/8	5/9	5/7	5/7	5/11
Aspen leafing	5/14	5/14	5/14	5/22	5/23	5/6	5/5	5/20	5/11	5/11	5/14
Blue-winged teal egg	5/12	5/14	5/19	5/11	5/22	5/18	5/14	5/21	5/11	5/13	5/15
Redhead egg	5/19	5/12	5/14	5/24	5/25	5/3	5/5	5/16	4/29	5/8	5/13
Yellow-headed blackbird egg	5/17	5/14	5/15	5/19	5/21	5/19	5/16	5/15	5/13	5/14	5/17
Dandelion blooming	5/17	5/18	5/17	5/24	5/31	5/12	5/10	—	5/19	5/17	5/17
Black tern	5/18	5/15	5/17	5/19	5/17	5/22	5/14	5/21	5/18	5/17	5/18
Red-winged blackbird egg	5/22	5/16	5/22	6/1	5/19	5/25	5/16	5/25	5/17	5/14	5/21
Sora egg	—	5/22	6/4	6/2	5/23	6/2	5/10	5/15	5/17	5/21	5/23
Chokecherry blooming	—	—	5/20	6/9	6/11	5/22	5/20	6/13	5/20	5/21	5/29
Ruddy duck egg	5/22	5/25	6/1	6/1	6/6	6/5	5/27	6/6	5/29	6/2	5/31
Black tern egg	—	6/9	6/7	6/1	6/8	6/10	6/9	6/9	—	6/7	6/8
Coots hatching	6/9	6/8	6/6	6/13	6/14	6/8	6/7	6/12	6/10	6/10	6/10
Young killdeer observation	—	6/10	6/8	6/17	—	—	—	—	6/26	6/20	6/16
Hen canvasback flocking	—	6/12	6/22	6/25	6/25	6/15	6/23	7/12	6/17	7/2	6/24

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238. Status Reports on Twelve Raptors, by David L. Evans. 1982. 68 pp.
239. Summary of Foreign Game Bird Liberations, 1969–78, by Richard C. Banks. 1981. 23 pp.
240. Reliability of Kill and Activity Estimates in the U.S. Waterfowl Hunter Survey, by Leigh M. Couling, A. R. Sen, and Elwood M. Martin. 1982. 14 pp.
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244. Technique for Structuring Wildlife Guilds to Evaluate Impacts on Wildlife Communities, by Henry L. Short and Kenneth P. Burnham. 1982.
245. Organochlorine Residues in Eggs of Alaskan Seabirds, by Harry M. Ohlendorf and others. 1982. 41 pp.
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